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Requirements and Assumptions in Visualization Process of Urban and Surrounding Areas (The Case Study of the Greek City in Time)

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Abstract. The visualization of urban areas requires specialized approach in software applications, in hardware equipment and on accuracy and pertinence of historical and archaeological data. The production of such representations requires the synthesis of a digital terrain model with a reconstruction of the build environment Most requirements for the digital reconstruction of an urban area are related to the vital functions of the city itself. Thus becomes necessary to establish criteria for the representativness of the studied samples, the reliability of methods of the research and its potential development, all elements. Researches and excavations of the ante-digital era are examined under the light of actual needs of information for reliable reconstructions. The publishing of the final product is related to the particular characteristics of each city, which, in turn, affects the choice of the most adapted visual form and the relevant degree of interactivity.

Keywords. GIS, virtual cartography, 3d visualization, interactivity, requirements, assumptions, realism, city, archaeology

1 Introduction

The startling improvements of the digital technology had direct effects on the planning and the reconstruction of cities. The new forms of visualization represent a wholly new process of elaboration.[1] Any reconstruction of a city, as a study matter, follows concrete requirements and assumptions of archaeological and historical nature. Its realization aims at a dynamic and virtual model, the publication of which undergoes the special elaboration demanded by the web environment. These are the circumstances, under which we carried out our case study and tried to set the framework for minimal requirements of geographical information for asite, of historical and archaeological data, of software tools for the creation of the model, and last but not least its usability for both scientific and educational purposes.

2 Visualization

The cartographic visualization, related to the recent development of computer science, is not a conjectural phenomenon. Its need has been felt since the very beginning and its “genealogy tree” links it to the scientific visualization, as well as to the cartographic visualization or geographic visualization.[2]

Cartographic animation may reflect changes in the time and thus we have temporal or non-temporal animation. It also may include 3D models, use movement and interactive formats and incorporate various information.

In our case we approached only non-temporal animation with either predefined movement (*avi*, *qtvr*, *mov*), or fully interactive movement (*vrml*).

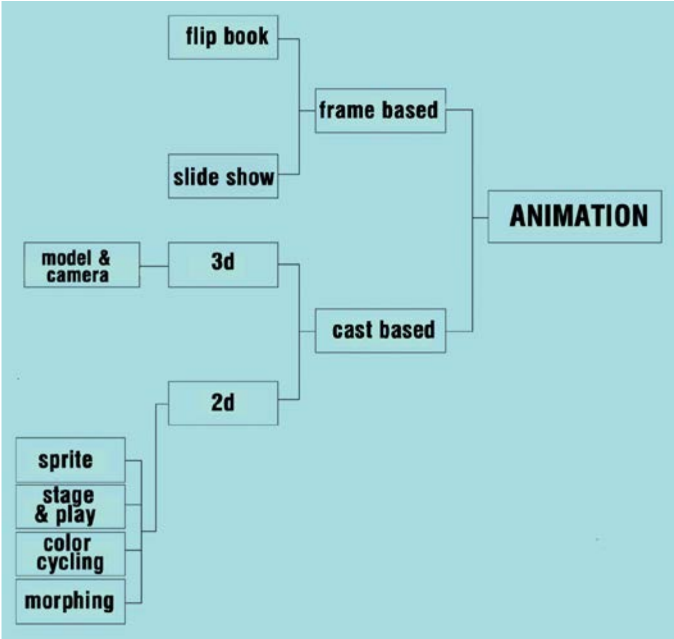

Fig. 1. *Different types of cartographic visualization.*

3 Publishing in the Web

The web is being increasingly adopted by new users, among which many national and international organizations, as one of the main vehicles for the transmission and spread of geo-information. It now seems that the web represents a one-way road for publishing, rather than a simple alternative.

The presentation of a 3-dimensional and interactive, geographical model, like the one we may today produce, ,

1 GIANNOULIS-GIANNOULOPOULOS G., SIDERIS A., 2002

2 PETERSON M.P., 1995.

implies large volumes and huge quantities of information, which may not be handled with the current transmission technology, [(as we found ourselves)] which is bound to small transmission rates, limited capacity channels and software and environment still in evolution. These facts condition the choice of the publishing format, as well as the selectivity of information to be incorporated.

4 The evolving appearance of the city during the time

The plan of the city underwent many changes in various cultural contexts. Most of the earliest cities are developed erratically around a central point, a palace or administrative building, which often combines religious and defensive functions. In Egyptian, Assyrian, Minoan and Mycenaean cities the fortified areas practically never coincide with the whole extend of the city. Later on, Classical Greek, Hellenistic, Roman and Byzantine cities adhere to a more organized plan, with a public area nucleus, which does not necessarily coincide with the geometric center of the settled surface. Boundaries become much clearer, since fortifications encompass now vast areas, covering eventually more than the area occupied by the settlement. Muslim cities evolved either on models of their predecessors, as did Ottoman and Iranian cities, or due to both climatic and cultural conditions, they adopted a labyrinth-like model. This pattern happened to have a wide application during the Middle Ages and through the symmetric and harmonious plans of the Renaissance resulted in the modern concept of the Open city.

5 Data/information requirements

The digital technology of the last decades imposed a dramatic change on the approaches of cartography and representation. They both now appear dynamic, virtual and interactive in strict contrast with the conventional or digital 2dimensional cartography.

5.1 Geographical, archaeological / historical

The representation of a city today takes into account totally new data. 3D modeling, movement, interactive formats and incorporated information set the framework for the creation and elaboration of any new visualization.

The city is one of the oldest themes of the visualization either in esthetic dependent or technically oriented forms. New visualization has dynamic character and is evolving in a digital environment. The static map becomes dynamic in a temporal or non-temporal approach. The representing capacities come closer to the human reality (virtual reality), while the user is allowed to adopt natural ways of seeing and a "reading" close to the everyday reality. The user may approach the object (city), fly over it, enter and tour it, and again measure the distance, which permits a better perception of size and volume.[3]

Concerning the archaeological and historical information the requirements include a general knowledge of the building plan of the city, with its particular elements, such as fortifications, large technical works (aqueducts, tunnels, terrain leveling) and public buildings (palaces, agora complexes, temples, theaters, baths, stadiums and other athletic or administrative complexes). Even then, the visualization produced may still be very partial.

Nevertheless the most important requirement for modeling is the knowledge of the organization of the urban zone, the urban tissue. Missing or inadequate information on it deprives our representation of the city from any scientific foundation and furthermore prohibits any pretension to realism. A general knowledge, at least, of the urban tissue is a *sine qua non* for the visualization of the city.

A first step towards the representation of any city, and specially in the case of Classical Greek and Byzantine examples, is the choice of scale. We'll need to clearly keep in mind the difference between the notions of "site" and "situation". The latter is suitable for architectural descriptions, whilst the former befits larger geographical entities, such as urban areas. The specific needs for readability lead us to varying technical solutions, which encompass scales from 1:1.000 up to 1:25.000, according to the aim of the representation.[4] In our case, as most often in cartography, we usually have applied larger scales.

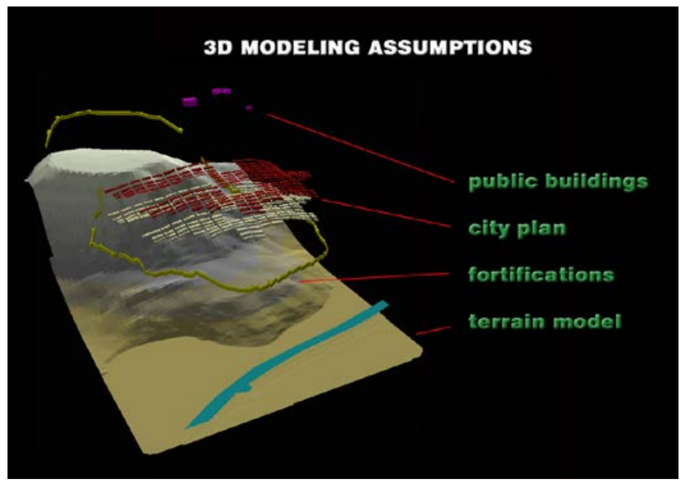

Fig. 2. *3D modeling assumptions in the case of Hellenistic Priene.*

5.2 Software, hardware and the human resources

Three types of programs have been used for our representations: *CAD*, *GIS* and *3D Modeling.*

Besides, the hardware equipment continues to play an important role. The exponential growth of computer power allowed the development of 3D modeling by College laboratories, private researchers and even talented amateurs.

In the process we should not underestimate the implication of the human factor. A major change is ongoing. The syllabus of almost every faculty of arts an humanities includes today at least some familiarization courses with the new technologies and their applications, whilst the faculties of applied sciences encourage their students to practice their newly acquired knowledge in cultural and most often archaeological context.

3 SIDERIS A., PALEOTHODOROS D. 2002

4 DOLFUS D. 1971, De BLIJ H.J. 1995.

6 Assumptions concerning the basic information

6.1 Accuracy and sufficiency of data

We rarely dispose of sufficient data for the representation of a whole city. We usually know better the areas connected with the public life, where the more splendorous and impressive structures are revealed. These give each city its original character and they often are invested with a symbolic function. Much less excavated and studied are the private houses, which are often known by a single example as in the case of Miletus, which nonetheless did not prevent archaeologists from proposing several slightly varying representations of the urban (tissue). The same situation is observed in Piraeus, where two excavated blocs of houses accounted for the whole city. This kind of assumptions among archaeologists, who usually luck founds, and time for further exploration, are quite frequent. From the point of view of a secondary knowledge manager / developer we can't but take them up. Many more issues are subject to assumptions as roofing systems, color of tiles, perishable materials used in visible parts of structures (wooden frames, doors and windows), architectural decoration, height of structures, decreasing density of urban tissue towards the periphery, etc. In order to work out a model we are often relegated, if not to conjectural solutions, at least to some hypothesis based on comparative material from other cities, even from different historical periods.

6.2 Fortuity in data collection and technological aging of finds

The cartographical 3D modeling cannot free us from bounds inherent to all historical disciplines as time selectivity. What survived today is not necessarily representative of what used to be the norm. Without textual and/or graphic information we cannot proceed to any representation. 3D modeling is based on secondary knowledge, and thought some new techniques are already under elaboration, for the time being we can't use primary information, directly from the sources, namely the cities concerned or their ruins.

Theories and viewpoints about a historical period change over time following new general scientific trends, newly acquired external or internal information, and even new synthesis and comprehension of preexisting data. Thus we have to face inadequacy of data produced by early excavations in the late 19th or early 20th centuries, the "golden age" of important archaeological missions. Drawings and sketches of those excavations rarely provide geographical coordinates, while the information on height results indirectly from symbols of esthetic value.

6.3 Importance of the assumptions and the viewpoint of the excavator

Dealing with the 3D virtual cartography of the Greek city in time, we often found ourselves relegated to the assumptions adopted by the excavator. Thought only assumptions, these are most likely the nearest to the truth. When we checked the information against the present state of ruins (whenever possible) we observed high precision, which in turn led us to admit excavator's viewpoint for other cases, where the material testimonies have in the meanwhile vanished.

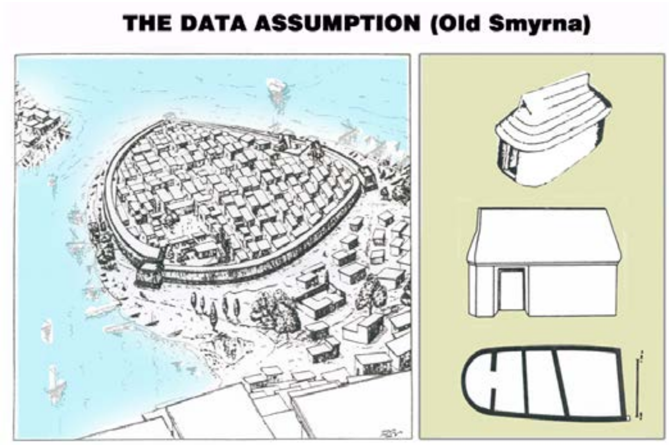

Fig. 3. The case of Old Smyrna. According to the excavator, the individual sample is an oval house, while in his reconstruction of the city he uses quadrangular houses.[5]

6.4 Uses and misuses of documents

Available documents are not of the same quality nor of the same utility for our purpose. Typical examples are the topographical maps, on which the isolines have a purely esthetic function, or maps on which the information has been deliberately altered, again as a concession to the esthetic result.

7 3D cartographical modeling

7.1 Model creation

3D cartographical modeling for cities is based on a bipolar scheme: a digital terrain model, over which unfolds a 3D representation of the urban tissue. Each of these entities is a separate object of a considerable information volume. Their inevitable coexistence decreases the resolution, and thus the detail of information, of both. A first step of the model creation consists in the elaboration of the "row" material usually pictures (in *pics* format), which need to be cleared, to become photo-mosaics and transformed in surfaces level.

A digitizing phase follows, during which attributes are allotted to all modeling elements (lines, points, polygons etc). In our case the project is produced partly by *AutoCAD*, and then exported to *3D analyst* (*ArcViewGIS*).

The projects, on which the above observations have been based, belong to the project plan of the Geographic Analysis and Cartography Laboratory of the Foundation of the Hellenic World. The Laboratory elaborates about 40 similar projects, in various degree of visualization, concerning mainly ancient Greek cities (http://gis.ime.gr/).

The Foundation of the Hellenic World disposes its own Cultural Center (http://www.ime.gr/cosmos/en/), with a high rate of visitor attendance, where the afore-mentioned models are on public display. The targets and requirements of the representation are set according to the visitors' remarks and evaluation, in an educational framework. Much more important is however the

[5] COOK, J. M. ,NICHOLLS, R. V. 1998.

evaluation resulting after consultancy with the researchers and excavators of these cities, who often visited the Laboratory and had directly assisted the interpretation process (as in the case of prof. Hoepfner, who supervised the models of Priene and Dura Europos). Many of the city models have been already presented in scientific publications.[6]

Concerning the sources of primary information for the cited models: Priene and Doura Europos are based on the publications of prof. Hoepfner.[7] The castle of Redina model follows the results of the excavations undertaken by the Byzantine Research Center of the University of Thessaloniki, lead by prof. Moutsopoulos.[8] The visualization of the city of Byzanitne Nikaia is based upon the results of the German Archaeological Institute of Istanbul.[9] The model of Hierapolis benefited from the results of the Italian expedition of the University Ca' Foscari of Venice, led by G.Traversasi, and those of the Franco-Canadian expedition under Des Gagners.[10]

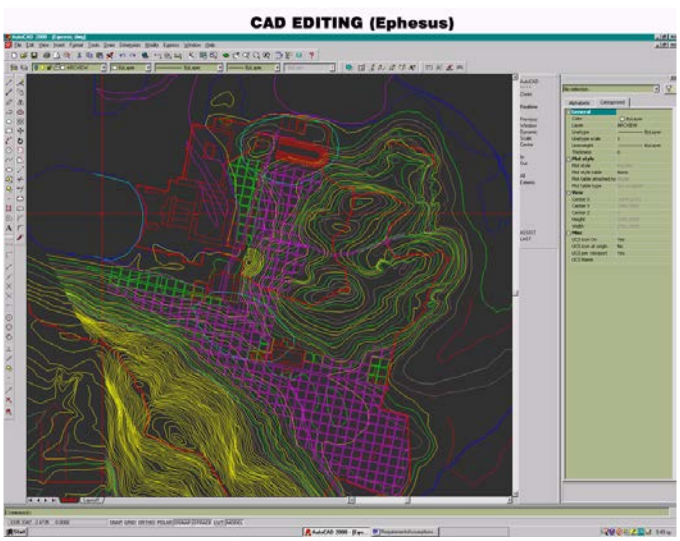

Fig. 4. *3D modeling process of the early 20th century Smyrna.*

7.2 Texture, lighting, camera and color rendering

The replacement of some elements of the model / map by other textures is necessary for the decrease of size. The elements of the map responsible for its large size are mainly two: the digital terrain model and the mass of blocks. In order to obtain a web adequate final size, we replace the *DTM* by its own image. The *DTM* is exported as a *geojpeg* (image with coordinates) and re-imported to drape and wrap the *DTM*. When the image has taken the shape of the *DTM*, we withdraw the latter. For the regarding buildings in our projects the default shapes proposed by *ArcView* are sufficient.

Lighting does not follow a plausible representation according to the sun trajectory. Omni and mainly directional spots are added to show the particularities of the model.

The program used for the production of cartographic animation is *3D Studio VIZ, in avi, qtvr, mov format*. We use a *Target Camera* with a 35 mm lens for wider shouting angle. We try to give the user the possibility to see the city from differents points of view. For this purpose we choose a trajectory for the camera like a spiral, which seems to be the more effective trajectory. We also provide for the end of the trajectory of the camera to coincide with a familiar 2-dimensional planimetric view, in order to give the user a reference point to the traditional cartography.

The last phase is the rendering. We've adopted a time configuration of 500 (25/1") for a "slow" movement, which enables the observation of the object without increasing the file size. The image resolution is min 640x480, and thus larger than the usual web examples (max 320x240). Requirements of web publishing sometimes impose even smaller aperture width. To decrease the size of files we regularly use video compression of *MPEG-4* type.

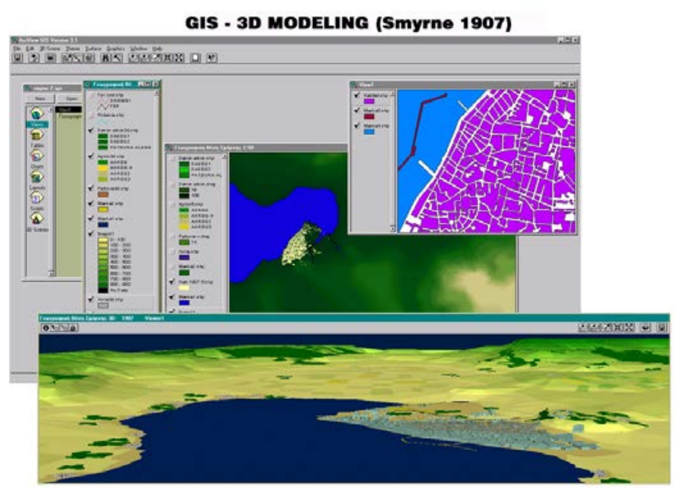

Fig. 5. *3D model of the Roman Hierapolis.*

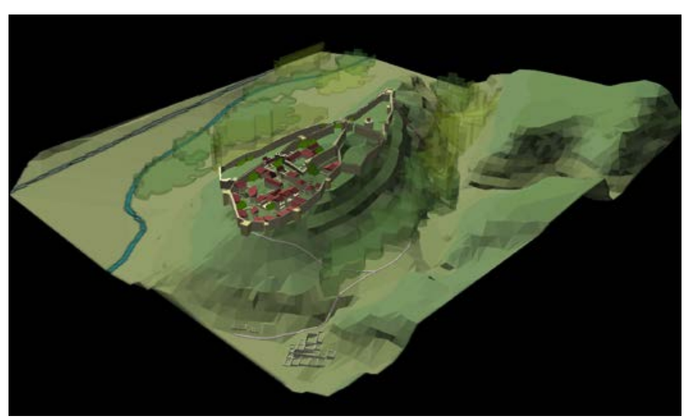

Fig. 6. *3D model of the Hellenistic Doura Europos.*

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6 SIDIROPOULOS G., PAPPAS V. 2002., CHRISTODOULOU V., SIDIROPOULOS G. 2002. , SIDIROPOULOS G., CHRISTODOULOU E. 2002., SIDIROPOULOS G. 2000.

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8 ΜΟΥΤΣΟΠΟΥΛΟΣ, Ν.Κ. 2001

9 SCHNEIDER A. 1943

10 BERTI F. 1993

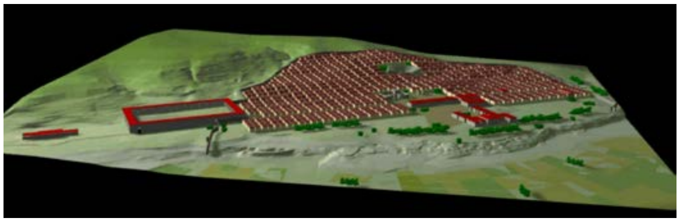

Fig. 7. 3D model of the late Byzantine Nicaea.

Fig. 8. 3D model of the middle Byzantine Rentina.

Fig. 9. 3D model of the Hellenistic Priene.

8 Conclusions

"One of the primordial uses of a map is to help the presentation of the topic we are about to deal with."[11] This statement however is not as "simple" as it may appear. To represent a city means to make comparisons, to understand the proportions, to show the site and situation for an entire area. It also means to discover detailed information for the land uses in the city or in its adjacent area, to locate all the important physical volumes, the infrastructure, the defense systems etc. These are nevertheless general requirements for any type of cartography, which become crucial for the virtual and 3D cartography, especially for the formats under consideration (*avi*, *qtvr, mov*), or (*vrml*), where the representation is enriched by several layers of information. The user is allowed to view the city from different view-points, different highs and different directions. Furthermore he/she is not any more dependent on symbols, as the isolines, which are replaced by the Digital Terrain Model or on conventions as the flat (2D) buildings replaced by 3D volumes.

The reasons for a different urban planning between a steep slope and a flat area become obvious through the virtual cartography, which uses models simulating the reality instead of symbols. Such DTMs may be used for further VR applications with educational or scientific goals.[12]

The possibility of incorporation of additional geographical, historical, archaeological and architectural information remains an open issue. Such information is usually available in the databases behind the model, but its presentation adopts more conventional forms such as audio capacities. As far as we are aware of the present state of research, no more interaction has been achieved beyond the mere navigation for the afore mentioned formats[13] and on this need should certainly focus the future research.

To recapitulate the observations, which defined and on the way modified our methodology in the project of "Greek City in Time", we have to meet requirements of a theoretical and of a practical order. The former include the decisions related to the purely scientific or educational scope of the visualization, the desired degree of interactivity, and the desired verisimilitude. The later comprise all requirements relevant to the information accuracy and completeness, to the information usability and to the readability of the model produced. Assumptions begin with the take up or rejection of earlier assumptions made by the excavator, most of which are applied on any visualization. Further assumptions are relevant to the actual web publishing limitations and may soon lose their importance. Finally other assumptions concern the training of the user-spectator's eye to the virtual world of artificial lighting, homogenous textures and symmetrical volumes.

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